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CLAIMS AMENDMENTS

Please amend claims 1 and 62. Please add new claims 36 and 96, which effectively reinstate with some amendment, earlier versions of these same-numbered claims that were cancelled in applicants' July 19, 2005 reply. All other claims are unchanged.

1 1. (currently amended) A system for identifying and measuring
2 concentrations of elements in fluids, comprising:
3   an ionic preconcentration cell, comprising:
4   an upper high surface area electrode comprising a high
5   specific surface area thereof;
6   a lower high surface area electrode comprising a high
7   specific surface area thereof, substantially parallel to
8   said upper high surface area electrode;
9   a central flow interelectrode gap separating said upper
10   and lower high surface area electrodes by a predetermined
11   interelectrode gap width; and
12   fluid flow means for flowing a fluid through said
13   central flow interelectrode gap; ~~and~~
14   <u>a computerized apparatus comprising calibration data related</u>
15   <u>to a rate at which photons are detected to be emitted from said</u>
16   <u>preconcentration cell based on a fluid of interest containing a</u>
17   <u>known concentration of at least one element of interest being</u>
18   <u>flowed at a known flow rate through said central flow</u>
19   <u>interelectrode gap for a known period of time, a known voltage</u>
20   <u>differential being applied across said electrodes, and said</u>
21   <u>preconcentration cell being exposed to x-rays; and</u>
22   <u>said computerized apparatus deducing an identity, or</u>

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23 measurement of concentration, of an unknown concentration of said

24 at least one element of interest in said fluid of interest, based

25 on comparing said calibration data with test data related to a

26 rate at which photons are detected to be emitted from said

27 preconcentration cell based on said fluid of interest with said

28 unknown concentration being flowed at a known flow rate through

29 said central flow interelectrode gap for a known period of time,

30 a known voltage differential being applied across said

31 electrodes, and said preconcentration cell being exposed to x-

32 rays.

33 ~~calibration data comprising background data related to a~~

34 ~~rate at which photons are detected to be emitted from at least~~

35 ~~one background data energy channel of said preconcentration cell~~

36 ~~or an equivalent cell, when said preconcentration cell or~~

37 ~~equivalent cell is filled with a highly purified form of a fluid~~

38 ~~of interest and exposed to x-rays.~~

1   2.   (original) The system of claim 1, further comprising:

2   voltage application means for applying a voltage

3   differential between said upper high surface area electrode and

4   said lower high surface area electrode while said fluid is

5   flowing through said central flow interelectrode gap.

1   3.   (previously presented) The system of claim 2, said voltage

2   application means further comprising:

3   a transportable voltage supply connected across said upper

4   and lower high surface area electrodes for applying an

5   electrostatic charge across said electrodes and thereby

6   maintaining ions from said at least one element entrained in said

4

7 electrodes during transport of said ionic preconcentration cell.

1 4. (previously presented) The system of claim 1, said ionic

2 preconcentration cell further comprising:

3   an upper x-ray transmission window in intimate contact with

4 an upper surface of said upper high surface area electrode.

1 5. (previously presented) The system of claim 4, said ionic

2 preconcentration cell further comprising:

3   a lower x-ray transmission window in intimate contact with a

4 lower surface of said lower high surface area electrode.

1 6. (original) The system of claim 1, said ionic

2 preconcentration cell further comprising:

3   inlet flow means for entering a fluid into said ionic

4 preconcentration cell and enabling said fluid to flow through

5 said central flow interelectrode gap.

1 7. (previously presented) The system of claim 6, said inlet

2 flow means comprising at least one planar inlet flow slot

3 substantially coplanar with said central flow interelectrode gap.

1 8. (previously presented) The system of claim 6, said inlet

2 flow means comprising a plurality of mutually-substantially

3 coplanar inlet flow tubes substantially coplanar with said

4 central flow interelectrode gap and substantially parallel with

5 one another.

1 9. (previously presented) The system of claim 6, said inlet

2 flow means comprising turbulence enhancement means for enhancing

3 a turbulence of the flow of said fluid to induce mixing of said

4 flow to enable uniform extraction of said at least one element

5 from the flow stream.

5

1   10.   (previously presented) The system of claim 6, said inlet

2   flow means comprising access means for accessing said inlet flow

3   means for physically cleaning debris therefrom.

1   11.   (original) The system of claim 1, said ionic

2   preconcentration cell further comprising:

3   outlet flow means for exiting said fluid out from said ionic

4   preconcentration cell after said fluid has flowed through said

5   central flow interelectrode gap.

1   12.   (previously presented) The system of claim 11, said

2   outlet flow means comprising at least one outlet flow slot

3   substantially coplanar with said central flow interelectrode gap.

1   13.   (previously presented) The system of claim 11, said

2   outlet flow means comprising a plurality of outlet flow tubes

3   substantially coplanar with said central flow interelectrode gap

4   and substantially parallel with one another.

1   14.   (previously presented) The system of claim 11, said

2   outlet flow means comprising access means for accessing said

3   outlet flow means for physically cleaning debris therefrom.

1   15.   (previously presented) The system of claim 4, said ionic

2   preconcentration cell further comprising:

3   a cell collector body maintaining a position of said upper

4   and lower high surface area electrodes and said upper x-ray

5   transmission window relative to one another, said cell collector

6   body in turn comprising a material comprising:

7   substantially no conductivity;

8   resistance to ionic leaching; and

9   resistance to radiation degradation from x-rays to

6

10   which said preconcentration cell is to be exposed.

1   16.   (previously presented) The system of claim 4, said ionic

2   preconcentration cell further comprising:

3   a cell collector body maintaining a position of said upper

4   and lower high surface area electrodes and said upper x-ray

5   transmission window relative to one another, said cell collector

6   body comprising a material selected from a material group

7   consisting of: plastic, glass, and fiberglass.

1   17.   (previously presented) The system of claim 4, said ionic

2   preconcentration cell further comprising:

3   a cell collector body maintaining a position of said upper

4   and lower high surface area electrodes and said upper x-ray

5   transmission window relative to one another, said cell collector

6   body comprising a non-conducting, machinable polymer

7   substantially resistant to radiation degradation.

1   18.   (previously presented) The system of claim 1:

2   said upper high surface area electrode further comprising an

3   upper electrode thickness less than or equal to approximately $\ell =$

4   $1/(\mu*\rho)$, wherein:

5   ℓ designates an optical depth of said upper high surface

6   area electrode when wetted with an element of interest for which

7   a fluidic concentration is to be measured, in said fluid;

8   μ designates a mass absorption coefficient of said upper

9   high surface area electrode when wetted with said element of

10   interest in said fluid; and

11   ρ designates a material density of said upper high surface

7

12   area electrode when wetted with said element of interest in said

13   fluid.

1   19.   (previously presented) The system of claim 18:

2   said lower high surface area electrode further comprising a

3   lower electrode thickness less than or equal to approximately ℓ =

4     $1/(\mu^* \rho)$, wherein:

5   ℓ designates an optical depth of said lower high surface

6   area electrode when wetted with an element of interest for which

7   a fluidic concentration is to be measured, in said fluid;

8   μ designates a mass absorption coefficient of said lower

9   high surface area electrode when wetted with said element of

10   interest in said fluid; and

11   ρ designates a material density of said lower high surface

12   area electrode when wetted with said element of interest in said

13   fluid.

1   20.   (original) The system of claim 1, said upper high surface

2   area electrode and said lower high surface area electrode further

3   comprising an ordinary surface area approximately equal to an

4   interrogation spot area of x-rays to which said preconcentration

5   cell is to be exposed.

1   21.   (previously presented) The system of claim 4, said upper

2   x-ray transmission window comprising a surface area approximately

3   equal to an interrogation spot area of x-rays to which said

4   preconcentration cell is to be exposed.

1   22.   (previously presented) The system of claim 2, said

2   central flow interelectrode gap comprising said predetermined

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3 interelectrode gap width, designated d, within an interelectrode

4 gap range specified by:

5 $$d = \frac{\sigma}{q\varepsilon} \frac{\Phi}{w_f} \frac{w_i}{n_f} \frac{A}{CF} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q\varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F},$$ wherein:

6 ε designates a predetermined percentage of at least one

7 element of interest to be extracted from said fluid, σ designates

8 a composite conductivity of said fluid, Φ designates a potential

9 applied by said voltage application means across said electrodes,

10 $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an

11 ordinary surface area covered by said electrodes, n_f designates a

12 number density of said fluid, w_i and w_f designate atomic /

13 molecular weights, respectively, of said at least one element of

14 interest and of said fluid, C designates a concentration of said

15 at least one element of interest in said fluid, and F designates

16 a flow rate of said fluid through said ionic preconcentration

17 cell;

18 said high surface area electrodes further comprise said

19 ordinary surface area A approximately equal to an interrogation

20 spot area of x-rays to which said preconcentration cell is to be

21 exposed;

22 said ε is chosen to be below approximately 5% for said at

23 least one element of interest;

24 said Φ is chosen to be below an electrochemical potential of

25 said at least one element of interest and below an electrolysis

26 potential of said fluid;

27 said F is chosen to exert no more than approximately .1 atm

28 of pressure upon an upper x-ray transmission window of said ionic

29 preconcentration cell in intimate contact with an upper surface

30 of said upper high surface area electrode;

31   said n_f and said w_f are chosen with reference to said at

32 least one element of interest; and

33   said w_i is chosen with reference to said fluid.

1 23.   (previously presented) The system of claim 22, said

2 central flow interelectrode gap comprising said predetermined

3 interelectrode gap width, d, with:

4   a minimum gap width selected from a minimum gap width group

5 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

6   a maximum gap width selected from a maximum gap width group

7 consisting of 2 mm, 5 mm, and 10 mm.

1 24.   (previously presented) The system of claim 4, said upper

2 x-ray transmission window comprising:

3   an atomic number below 10;

4   structural rigidity to support up to 1/10 atm. of pressure

5 without bowing more than approximately 100 microns;

6   substantial impermeability relative to said fluid;

7   x-ray transparency greater than 90% for characteristic

8 photon energies from an element of interest for which a fluidic

9 concentration is to be measured;

10   x-ray scattering therefrom minimized to less than

11 approximately 10% of radiation scattered from a column of said

12 fluid equal to one optical depth in said fluid of a

13 characteristic photonic energy from an element of interest for

14 which a fluidic concentration is to be measured; and

10

15   freedom from any single contaminant in excess of 1 part per

16   million, when measured by x-ray fluorescence.

1   25.   (previously presented)   The system of claim 5, said lower

2   x-ray transmission window comprising:

3   an atomic number below 10;

4   structural rigidity to support up to 1/10 atm. of pressure

5   without bowing more than approximately 100 microns;

6   substantial impermeability relative to said fluid;

7   x-ray transparency greater than 90% for characteristic

8   photon energies from an element of interest for which a fluidic

9   concentration is to be measured;

10   x-ray scattering therefrom minimized to less than

11   approximately 10% of radiation scattered from a column of said

12   fluid equal to one optical depth in said fluid of a

13   characteristic photonic energy from an element of interest for

14   which a fluidic concentration is to be measured; and

.15   freedom from any single contaminant in excess of 1 part per

16   million, when measured by x-ray fluorescence.

1   26.   (previously presented)   The system of claim 4, said upper

2   x-ray transmission window comprising a polyimid film comprising

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns.

1   27.   (previously presented)   The system of claim 5, said lower

2   x-ray transmission window comprising a polyimid film comprising

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns.

1   28.   (previously presented)   The system of claim 1:

11

2   said upper high surface area electrode and said lower high

3   surface area electrode each comprising a high surface area

4   material in turn comprising:

5   a large plurality of pores characterized by a specific

6   surface area of at least approximately 100 m^2/g;

7   an average pore diameter of said pores between approximately

8   30 nm and 10 nm per pore;

9   a distribution of the pore diameters grouped with a standard

10 deviation of less than approximately 10nm around said average

11 pore diameter;

12   an x-ray transparency greater than approximately 90% for

13 characteristic photon energies from an element of interest for

14 which a fluidic concentration is to be measured;

15   electrical conductivity of 10-40 mOhms-cm when fabricated

16 into a ¼ mm thick electrode;

17   the ability to contain approximately at least 0.1% by weight

18 of foreign material relative to said high surface area material

19 prior to saturation;

20   high structural rigidity wherein a displacement under the

21 flow of said fluid does not exceed approximately 0.25mm;

22   high wetting ability wherein an approximately ¼ mm thick

23 sheet of said high surface area material becomes substantially

24 wetted in less than approximately three seconds; and

25   freedom from metallic impurities in excess of approximately

26 .5 parts per million, when measured by x-ray fluorescence

27 analysis.

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1   29.   (previously presented)   The system of claim 28, said large

2   plurality of pores characterized by a specific surface area of at

3   least approximately 400 m^2/g.

1   30.   (previously presented)   The system of claim 28, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m^2/g.

1   31.   (previously presented)   The system of claim 29, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m^2/g.

1   32. (previously presented)   The system of claim 1, said upper

2   high surface area electrode and said lower high surface area

3   electrode each comprising a high surface area material in turn

4   comprising:

5   an x-ray transparency greater than approximately 90% for

6   characteristic photon energies from an element of interest for

7   which a fluidic concentration is to be measured.

1   33. (original)   The system of claim 1, said upper high surface

2   area electrode and said lower high surface area electrode each

3   comprising a carbon aerogel.

1   34.   (previously presented)   The system of claim 1, said upper

2   high surface area electrode comprising a thickness less than

3   approximately $\ell = 1/(\mu*\rho)$; wherein:

4   ℓ designates an optical depth of said upper high surface

5   area electrode when wetted with said fluid;

6   μ designates a mass absorption coefficient of said high

7   surface area electrode when wetted with said fluid; and

8   ρ designates a density of said high surface area electrode

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9   when wetted with said fluid.

1   35.   (previously presented) The system of claim 34, said lower

2   high surface area electrode comprising a thickness less than

3   approximately $\ell = 1/(\mu*\rho)$; wherein:

4   ℓ designates an optical depth of said lower high surface

5   area electrode when wetted with said fluid;

6   μ designates a mass absorption coefficient of said lower

7   surface area electrode when wetted with said fluid; and

8   ρ designates a density of said lower surface area electrode

9   when wetted with said fluid.

1   36.   (cancelled)

1   37.   (previously presented) The system of claim 1, said

2   calibration data further comprising:

3   sensitivity data related to a rate at which photons are

4   detected to be emitted from at least one sensitivity data energy

5   channel of said preconcentration cell, when said preconcentration

6   cell is filled with a first calibration solution, containing at

7   least one element of interest in a fluid of interest in known

8   concentration above a minimum detection level of x-ray detection

9   equipment to be used for said detecting and measuring, and when

10 said preconcentration cell is exposed to x-rays.

1   38.   (previously presented) The system of claim 2, said

2   calibration data further comprising:

3   ion extraction rate data related to a rate at which photons

4   are detected to be emitted from at least one ion extraction rate

5   data energy channel of said preconcentration cell, when a

6   calibration solution, containing said at least one element of

14

7   interest in a fluid of interest in known concentration below a

8   minimum detection level of x-ray detection equipment to be used

9   for said detecting and measuring, is flowed through the central

10   flow interelectrode gap of said preconcentration cell, at a

11   substantially constant flow rate, while the voltage application

12   means applies the voltage differential across the electrodes of

13   said preconcentration cell, below an electrochemical potential of

14   said at least one element of interest and below an electrolysis

15   potential of said calibration solution, and when said

16   preconcentration cell is exposed to x-rays.

1   39.   (previously presented) The system of claim 2, said

2   calibration data further comprising:

3   background data related to a rate at which photons are

4   detected to be emitted from at least one background data energy

5   channel of said preconcentration cell, when said preconcentration

6   cell is filled with a highly purified form of a fluid of interest

7   and exposed to x-rays;

8   sensitivity data related to a rate at which photons are

9   detected to be emitted from at least one sensitivity data energy

10   channel of said preconcentration cell, when said preconcentration

11   cell is filled with a first calibration solution, containing at

12   least one element of interest in said fluid of interest in known

13   concentration above a minimum detection level of x-ray detection

14   equipment to be used for said detecting and measuring, and when

15   said preconcentration cell is exposed to x-rays; and

16   ion extraction rate data related to a rate at which photons

17   are detected to be emitted from at least one ion extraction rate

18   data energy channel of said preconcentration cell, when a second

19   calibration solution, containing said at least one element of

20   interest in said fluid of interest in known concentration below

21   said minimum detection level of x-ray detection equipment to be

22   used for said detecting and measuring, is flowed through the

23   central flow interelectrode gap of said preconcentration cell, at

24   a substantially constant flow rate, while the voltage application

25   means applies the voltage differential across the electrodes of

26   said preconcentration cell, below an electrochemical potential of

27   said at least one element of interest and below an electrolysis

28   potential of said second calibration solution, and when said

29   preconcentration cell is exposed to x-rays.

1   40.   (previously presented) The system of claim 2, further

2   comprising:

3   test data accumulation means for obtaining said test data

4   comprising data related to a rate at which photons are detected

5   to be emitted from at least one energy channel of said

6   preconcentration cell when said fluid, suspected to contain at

7   least one element of interest, is flowed through said central

8   flow interelectrode gap at a substantially constant flow rate,

9   while said voltage application means applies said voltage

10   differential across said electrodes below an electrochemical

11   potential of said at least one element of interest and below an

12. electrolysis potential of said fluid, and when said

13   preconcentration cell is exposed to x-rays.

1   41.   (original) The system of claim 40, further comprising:

2   analysis means for analyzing said test data and deducing

16

3   therefrom a concentration in said fluid, if any, of the suspected

4   at least one element of interest.

1   42.   (previously presented) The system of claim 39, further

2   comprising:

3   test data accumulation means for obtaining said test data

4   comprising data related to a rate at which photons are detected

5   to be emitted from at least one energy channel of said

6   preconcentration cell when said fluid, suspected to contain at

7   least one element of interest, is flowed through said central

8   flow interelectrode gap at a substantially constant flow rate,

9   while said voltage application means applies said voltage

10   differential across said electrodes below an electrochemical

11   potential of said at least one element of interest and below an

12   electrolysis potential of said fluid, and when said

13   preconcentration cell is exposed to x-rays.

1   43.   (original) The system of claim 42, further comprising:

2   analysis means for analyzing said test data in relation to

3   said background data, said sensitivity data, and said ion

4   extraction rate data, and deducing therefrom a concentration in

5   said fluid, if any, of the suspected at least one element of

6   interest.

1   44.   (previously presented) The system of claim 4, further

2   comprising:

3   voltage application means for applying a voltage

4   differential between said upper high surface area electrode and

5   said lower high surface area electrode while said fluid is

6   flowing through said central flow interelectrode gap; and

17

7   x-ray source means positioned and aligned relative to said

8   upper x-ray transmission window for exposing said

9   preconcentration cell to x-rays substantially transmitted through

10   said upper x-ray transmission window, while flowing said fluid

11   and while applying said voltage differential.

1   45.   (previously presented) The system of claim 2, said

2   voltage application means further comprising:

3   a transportable voltage supply for applying an electrostatic

4   charge across said electrodes and thereby maintaining ions from

5   said at least one element entrained in said electrodes during

6   transport of said ionic preconcentration cell: after ceasing flow

7   of said fluid, while transporting said ionic preconcentration

8   cell to an x-ray source means for emitting x-rays toward said

9   preconcentration cell, and while exposing said preconcentration

10   cell to x-rays.

1   46.   (original) The system of claim 1, further comprising:

2   flow control means for controlling a flow rate of said fluid

3   through said ionic preconcentration cell so as to maintain ε,

4   which designates a predetermined percentage of at least one

5   element of interest to be extracted from said fluid, below

6   approximately 5% for said at least one element of interest.

1   47.   (previously presented) The system of claim 46, wherein

2   said ε is maintained below an extraction percentage selected from

3   an extraction percentage group consisting of approximately 4%,

4   3%, 2%, and 1%.

1   48.   (previously presented) The system of claim 2, further

2   comprising flow control means for:

18

3   controlling a flow rate F of said fluid through said ionic

4   preconcentration cell and maintaining said F at a substantially

5   constant level so as to maintain ε, which designates a

6   predetermined percentage of at least one element of interest to

7   be extracted from said fluid and is specified by:

8
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{q\,d}\,\frac{w_i}{w_f}\,\frac{A}{n_f C F}\times 100\%,$$

9   below approximately 5% for said at least one element of interest;

10   wherein:

11   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

12   one element of interest are respectively extracted from said

13   fluid by said cell and supplied to said cell by said fluid, σ

14   designates a composite conductivity of said fluid, Φ designates

15   a potential applied by said voltage application means across said

16   electrodes, d designates said predetermined interelectrode gap

17   width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$

18   Coulomb designates the unit charge, A designates an ordinary

19   surface area covered by said electrodes, n_f designates a number

20   density of said fluid, w_i and w_f designate atomic / molecular

21   weights, respectively, of said at least one element of interest

22   and of said fluid, and C designates a concentration of said at

23   least one element of interest in said fluid; and

24   for having said concentration C in a range where

25   conductivity varies substantially linearly with concentration,

26   with C in units of parts per billion, wherein σ is approximated

27   by:

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28      $\sigma \approx 2 \times 10^{-9} \, C/Ohm - cm$.

1   49.   (previously presented)   The system of claim 48, wherein

2   said ε is maintained below an extraction percentage selected from

3   an extraction percentage group consisting of approximately 4%,

4   3%, 2%, and 1%.

1   50.   (original)   The system of claim 2, said voltage

2   application means applying said voltage differential across said

3   electrodes below an electrochemical potential of at least one

4   element of interest and below an electrolysis potential of said

5   fluid.

1   51.   (previously presented)   The system of claim 1, further

2   comprising:

3   leakage current monitoring means for monitoring a total non-

4   saturated concentration of dissolved ions in said upper and lower

5   high surface area electrodes, by monitoring a leakage current

6   from said cell.

1   52.   (previously presented)   The system of claim 51, further

2   comprising:

3   ultra-low trace measuring means for measuring at least one

4   element of interest comprising ultra-low trace, high valence ions

5   in said fluid, based on said detecting the non-saturated

6   saturation state.

1   53.   (previously presented)   The system of claim 1, further

2   comprising:

3   leakage current monitoring means for monitoring a total non-

4   saturated concentration of dissolved ions in said upper and lower

5   high surface area electrodes; and

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6   flow rate adjustment means for adjusting the flow of said

7   fluid through said ionic preconcentration cell to control a

8   percentage of said ions extracted from said fluid, based on said

9   monitoring of said leakage current by said leakage current

10 monitoring means.

1   54.   (previously presented)   The system of claim 1, further

2   comprising:

3   time control means for controlling how long said fluid flows

4   through said ionic preconcentration cell based on setting an

5   impurity concentration C, in a range where conductivity varies

6   substantially linearly with concentration, to a predetermined

7   desired concentration detection level and flowing said fluid for

8   a time t given by:

9        $$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C};\ \text{wherein:}$$

10 S designates a sensitivity of x-ray detection equipment to

11 be used for said detecting and measuring;

12 ℓ designates a thickness of said upper high surface area

13 electrode; and

14 σ designates a composite conductivity of said fluid.

1   55.   (previously presented)   The system of claim 1, further

2   comprising triggering means for triggering an action in response

3   to said system detecting that a concentration of at least one

4   element of interest in said fluid has passed a predetermined,

5   non-saturated threshold concentration.

1   56.   (previously presented)   The system of claim 55, further

2   comprising injection action means for injecting at least one

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3   element into said fluid, thereby maintaining said concentration

4   within a predetermined concentration range, as said action in

5   response to said triggering means.

1   57.   (previously presented) The system of claim 55, further

2   comprising dilution action means for diluting at least one

3   diluting fluid into said fluid, thereby maintaining said

4   concentration within a predetermined concentration range, as said

5   action in response to said triggering means.

1   58.   (previously presented) The system of claim 1, further

2   comprising:

3   ionic release means for cleaning said preconcentration cell

4   after use by releasing ions accumulated within said high specific

5   surface area of said electrodes into said fluid, after the

6   accumulated ions have been exposed to x-rays and fluorescence

7   from said preconcentration cell has been detected.

1   59.   (previously presented) The system of claim 4, further

2   comprising:

3   x-ray source means positioned and aligned relative to said

4   upper x-ray transmission window for emitting x-rays toward said

5   preconcentration cell substantially transmitted through said

6   upper x-ray transmission window; and

7   x-ray fluorescence detector means positioned and aligned

8   relative to said upper x-ray transmission window for detecting

9   fluoresced energy emitted by said preconcentration cell due to

10 said emitting x-rays toward said preconcentration cell, through

11 said upper x-ray transmission window.

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1   60.   (previously presented) The system of claim 59, further

2   comprising:

3   x-ray fluorescence analysis means for analyzing the detected

4   x-ray fluoresced energy and deducing therefrom a concentration in

5   said fluid of at least one element of interest in said fluid.

1   61.   (previously presented) The system of claim 1, further

2   comprising:

3   a telecommunications link for downloading and analyzing said

4   test data from said ionic preconcentration cell.

1   62.   (currently amended) A method for identifying and

2   measuring concentrations of elements in fluids, comprising the

3   steps of:

4   flowing a fluid through a central flow interelectrode gap of

5   an ionic preconcentration cell separating an upper high specific

6   surface area electrode from a lower high specific surface area

7   electrode of said ionic preconcentration cell by a predetermined

8   interelectrode gap width;

9   applying a <u>known</u> voltage differential between said upper

10 high surface area electrode and said lower high surface area

11 electrode while said fluid is flowing through said central flow

12 interelectrode gap;

13   exposing said cell to x-rays; and ~~under test conditions and~~

14 ~~obtaining test data characterizing a response thereto of said~~

15 ~~cell; and~~

16 ~~deducing an identity, or measurement of concentration, of at~~

17 ~~least one element in said fluid, using said test data in~~

18 ~~combination with calibration data,~~

23

19 deducing an an identity, or measurement of concentration, of

20 an unknown concentration of at least one element of interest in

21 said a fluid of interest, based on comparing calibration data

22 with test data related to a rate at which photons are detected to

23 be emitted from said preconcentration cell based on said fluid of

24 interest with said unknown concentration flowing through said

25 central flow interelectrode gap at a known flow rate for a known

26 period of time together with said applying said known voltage

27 differential and said exposing said cell to x-rays, wherein said

28 calibration data is obtained by:

29   flowing a fluid of interest containing a known concentration

30 of at least one element of interest through said central flow

31 interelectrode gap at a known rate for a known period of

32 time~~filling said preconcentration cell, with a highly purified~~

33 ~~form of a fluid of interest~~;

34   applying a known voltage differential across said electrodes

35   exposing the ~~filled~~ preconcentration cell to x-rays; and

36   acquiring data related to a rate at which photons are

37 detected to be emitted from said preconcentration cell~~background~~

38 ~~data related to a rate at which photons are detected to be~~

39 ~~emitted from at least one background data energy channel of said~~

40 ~~preconcentration cell; and~~

41 ~~   associating said background data with said preconcentration~~

42 ~~cell~~.

1 63.   (previously presented) The method of claim 62, said step

2 of applying said voltage differential further comprising the step

3 of:

24

4   applying an electrostatic charge across said electrodes and

5   thereby maintaining ions from said at least one element entrained

6   in said electrodes during transport of said ionic

7   preconcentration cell, using a transportable voltage supply.

1   64.   (previously presented) The method of claim 62, further

2   comprising the step of:

3   intimately contacting an upper surface of said upper high

4   surface area electrode with an upper x-ray transmission window of

5   said ionic preconcentration cell.

1   65.   (previously presented) The method of claim 64, further

2   comprising the step of:

3   intimately contacting a lower surface of said lower high

4   surface area electrode with a lower x-ray transmission window of

5   said ionic preconcentration cell.

1   66.   (original) The method of claim 62, further comprising the

2   steps of:

3   entering a fluid into said ionic preconcentration cell using

4   inlet flow means therefor; and

5   enabling said fluid to flow through said central flow

6   interelectrode gap.

1   67.   (previously presented) The method of claim 66, said step

2   of entering said fluid further comprising entering said fluid

3   through said inlet flow means comprising at least one mutually-

4   planar inlet flow slot substantially coplanar with said central

5   flow interelectrode gap.

1   68.   (previously presented) The method of claim 66, said step

2   of entering said fluid further comprising entering said fluid

25

3   through said inlet flow means comprising a plurality of

4   substantially coplanar inlet flow tubes substantially coplanar

5   with said central flow interelectrode gap and substantially

6   parallel with one another.

1   69.   (previously presented) The method of claim 66, further

2   comprising the step of enhancing a turbulence of the flow of said

3   fluid while entering said fluid, thereby inducing mixing of said

4   flow for enabling uniform extraction of said at least one element

5   from the flow stream.

1   70.   (previously presented) The method of claim 66, further

2   comprising the step of physically cleaning debris from said inlet

3   flow means using access means for accessing said inlet flow

4   means.

1   71.   (original) The method of claim 62, further comprising the

2   step of:

3   exiting said fluid out from said ionic preconcentration cell

4   after said fluid has flowed through said central flow

5   interelectrode gap using outlet flow means therefor.

1   72.   (previously presented) The method of claim 71, said step

2   of exiting said fluid further comprising exiting said fluid

3   through said outlet flow means comprising at least one outlet

4   flow slot substantially coplanar with said central flow

5   interelectrode gap.

1   73.   (previously presented) The method of claim 71, said step

2   of exiting said fluid further comprising exiting said fluid

3   through said outlet flow means comprising a plurality of outlet

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4   flow tubes substantially coplanar with said central flow

5   interelectrode gap and substantially parallel with one another.

1   74.   (previously presented) The method of claim 71, further

2   comprising the step of physically cleaning debris from said

3   outlet flow means using access means for accessing said outlet

4   flow means.

1   75.   (previously presented) The method of claim 64, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using a body of said ionic preconcentration cell

6   comprising a material comprising:

7   substantially no conductivity;

8   resistance to ionic leaching; and

9   resistance to radiation degradation from x-rays to

10   which said preconcentration cell is to be exposed.

1   76.   (previously presented) The method of claim 64, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using a body of said ionic preconcentration cell

6   comprising a material selected from a material group consisting

7   of: plastic, glass, and fiberglass.

1   77.   (previously presented) The method of claim 64, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

27

5 to one another, using a body of said ionic preconcentration cell

6 comprising a material comprising a non-conducting, machinable

7 polymer substantially resistant to radiation degradation.

1 78.   (previously presented)   The method of claim 62, further

2 comprising the step of:

3   providing said upper high surface area electrode with an

4 upper electrode thickness thereof less than or equal to

5 approximately $\ell = 1/(\mu*\rho)$, wherein:

6   ℓ designates an optical depth of said upper high surface

7 area electrode when wetted with an element of interest for which

8 a fluidic concentration is to be measured, in said fluid;

9   μ designates a mass absorption coefficient of said upper

10 high surface area electrode, when wetted with said element of

11 interest in said fluid; and

12   ρ designates a material density of said upper high surface

13 area electrode, when wetted with said element of interest in said

14 fluid.

1 79.   (previously presented)   The method of claim 78, further

2 comprising the step of:

3   providing said lower high surface area electrode with a

4 lower electrode thickness thereof less than or equal to

5 approximately $\ell = 1/(\mu*\rho)$, wherein:

6   ℓ designates an optical depth of said lower high surface

7 area electrode when wetted with an element of interest for which

8 a fluidic concentration is to be measured, in said fluid;

9   μ designates a mass absorption coefficient of said lower

28

10   high surface area electrode, when wetted with said element of

11   interest in said fluid; and

12   ρ designates a material density of said lower high surface

13   area electrode, when wetted with said element of interest in said

14   fluid.

1   80.   (original) The method of claim 62, further comprising the

2   step of:

3   providing ordinary surface areas of said upper high surface

4   area electrode and said lower high surface area electrode

5   approximately equal to an interrogation spot area of x-rays to

6   which said preconcentration cell is to be exposed.

1   81.   (previously presented) The method of claim 64, further

2   comprising the step of:

3   providing a surface area of said upper x-ray transmission

4   window approximately equal to an interrogation spot area of x-

5   rays to which said preconcentration cell is to be exposed.

1   82.   (previously presented) The method of claim 62, further

2   comprising the step of:

3   providing said central flow interelectrode gap comprising

4   said predetermined interelectrode gap width, designated d, within

5   an interelectrode gap range specified by:

6
$$d = \frac{\sigma \Phi}{q\varepsilon} \frac{w_i}{w_f} \frac{A}{n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q\varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F} ;$$ wherein:

7   ε designates a predetermined percentage of at least one

8   element of interest to be extracted from said fluid, σ designates

9   a composite conductivity of said fluid, Φ designates said

10   voltage differential applied across said electrodes, $q = 1.60 \times 10^{-}$

29

11 [19] Coulomb designates the unit charge, A designates an ordinary

12 surface area covered by said electrodes, n_f designates a number

13 density of said fluid, w_i and w_f designate atomic / molecular

14 weights, respectively, of said at least one element of interest

15 and of said fluid, C designates a concentration of said at least

16 one element of interest in said fluid, and F designates a flow

17 rate of said fluid through said ionic preconcentration cell;

18   said high surface area electrodes further comprise said

19 ordinary surface area A approximately equal to an interrogation

20 spot area of x-rays to which said preconcentration cell is to be

21 exposed;

22   said ε is chosen to be below approximately 5% for said at

23 least one element of interest;

24   said Φ is chosen to be below an electrochemical potential of

25 said at least one element of interest and below an electrolysis

26 potential of said fluid;

27   said F is chosen to exert no more than approximately .1 atm

28 of pressure upon an upper x-ray transmission window of said ionic

29 preconcentration cell in intimate contact with an upper surface

30 of said upper high surface area electrode;

31   said n_f and said w_f are chosen with reference to said at

32 least one element of interest; and

33   said w_i is chosen with reference to said fluid.

1 83.   (previously presented) The method of claim 82, further

2 comprising the step of:

3   providing said central flow interelectrode gap comprising

4 said predetermined interelectrode gap width, d, with:

30

5   a minimum gap width selected from a minimum gap width group

6   consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

7   a maximum gap width selected from a maximum gap width group

8   consisting of 2 mm, 5 mm, and 10 mm.

1   84.   (previously presented) The method of claim 64, further

2   comprising the step of providing said upper x-ray transmission

3   window comprising:

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9   photon energies from an element of interest for which a fluidic

10   concentration is to be measured;

11   x-ray scattering therefrom minimized to less than

12   approximately 10% of radiation scattered from a column of said

13   fluid equal to one optical depth in said fluid of a

14   characteristic photonic energy from an element of interest for

15   which a fluidic concentration is to be measured; and

16   freedom from any single contaminant in excess of 1 part per

17   million, when measured by x-ray fluorescence.

1   85.   (previously presented) The method of claim 65, further

2   comprising the step of providing said lower x-ray transmission

3   window comprising:

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

31

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9 photon energies from an element of interest for which a fluidic

10 concentration is to be measured;

11   x-ray scattering therefrom minimized to less than

12 approximately 10% of radiation scattered from a column of said

13 fluid equal to one optical depth in said fluid of a

14 characteristic photonic energy from an element of interest for

15 which a fluidic concentration is to be measured; and

16   freedom from any single contaminant in excess of 1 part per

17 million, when measured by x-ray fluorescence.

1 86.   (previously presented) The method of claim 64, further

2 comprising the step of:

3   providing said upper x-ray transmission window comprising a

4 polyimid film comprising structural rigidity to support up to

5 1/10 atm. of pressure without bowing more than approximately 100

6 microns.

1 87.   (previously presented) The method of claim 65, further

2 comprising the step of:

3   providing said lower x-ray transmission window comprising a

4 polyimid film comprising structural rigidity to support up to

5 1/10 atm. of pressure without bowing more than approximately 100

6 microns.

1 88.   (previously presented) The method of claim 62 further

2 comprising the step of:

3   providing said upper high surface area electrode and said

4 lower high surface area electrode each comprising a high surface

32

5   area material in turn comprising:

6   a large plurality of pores characterized by a specific

7   surface area of at least approximately 100 m^2/g;

8   an average pore diameter of said pores between approximately

9   30 nm and 10 nm per pore;

10   a distribution of the pore diameters grouped with a standard

11   deviation of less than approximately 10nm around said average

12   pore diameter;

13   an x-ray transparency greater than approximately 90% for

14   characteristic photon energies from an element of interest for

15   which a fluidic concentration is to be measured;

16   electrical conductivity of 10-40 mOhms-cm when fabricated

17   into a ¼ mm thick electrode;

18   the ability to contain approximately at least 0.1% by weight

19   of foreign material relative to said high surface area material

20   prior to saturation;

21   high structural rigidity wherein a displacement under the

22   flow of said fluid does not exceed approximately 0.25mm;

23   high wetting ability wherein an approximately ¼ mm thick

24   sheet of said high surface area material becomes substantially

25   wetted in less than approximately three seconds; and

26   freedom from metallic impurities in excess of approximately

27   .5 parts per million, when measured by x-ray fluorescence

28   analysis.

1   89.   (previously presented) The method of claim 88, said large

2   plurality of pores characterized by a specific surface area of at

3   least approximately 400 m^2/g.

33

1   90.   (previously presented)   The method of claim 88, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m^2/g.

1   91.   (previously presented)   The method of claim 89, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m^2/g.

1   92.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   providing said upper high surface area electrode and said

4   lower high surface area electrode each comprising a high surface

5   area material in turn comprising:

6   an x-ray transparency greater than approximately 90% for

7   characteristic photon energies from an element of interest for

8   which a fluidic concentration is to be measured.

1   93.   (original) The method of claim 62, further comprising the

2   step of:

3   providing said upper high surface area electrode and said

4   lower high surface area electrode each comprising a carbon

5   aerogel.

1   94.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   providing said upper high surface area electrode with a

4   thickness less than approximately $\ell = 1/(\mu*\rho)$; wherein:

5   ℓ designates an optical depth of said upper high surface

6   area electrode when wetted with said fluid;

7   μ designates a mass absorption coefficient of said high

8   surface area electrode when wetted with said fluid; and

34

9   ρ designates a density of said high surface area electrode

10   when wetted with said fluid.

1   95.   (previously presented)   The method of claim 94, further

2   comprising the step of:

3   providing said lower high surface area electrode with a

4   thickness less than approximately $\ell = 1/(\mu*\rho)$; wherein:

5   ℓ designates an optical depth of said lower high surface

6   area electrode when wetted with said fluid;

7   μ designates a mass absorption coefficient of said lower

8   surface area electrode when wetted with said fluid; and

9   ρ designates a density of said lower surface area electrode

10   when wetted with said fluid.

1   96.   (cancelled)

1   97.   (previously presented)   The method of claim 62, further

2   comprising the step of obtaining said calibration data by:

3   filling said preconcentration cell, with a first calibration

4   solution containing at least one element of interest in a fluid

5   of interest in known concentration above a minimum detection

6   level of x-ray detection equipment to be used for said detecting

7   and measuring;

8   exposing the filled preconcentration cell to x-rays;

9   acquiring sensitivity data related to a rate at which

10   photons are detected to be emitted from at least one sensitivity

11   data energy channel of said preconcentration cell; and

12   associating said sensitivity data with said preconcentration

13   cell.

35

1   98.   (previously presented) The method of claim 62, further

2   comprising the step of obtaining said calibration data by:

3   applying said voltage differential across the electrodes of

4   said preconcentration cell, below an electrochemical potential of

5   said at least one element of interest and below an electrolysis

6   potential of a calibration solution;

7   flowing said calibration solution containing said at least

8   one element of interest in a fluid of interest in known

9   concentration below a minimum detection level of x-ray detection

10   equipment to be used for said detecting and measuring through the

11   central flow interelectrode gap of said preconcentration cell at

12   a substantially constant flow rate;

13   exposing said preconcentration cell with said calibration

14   solution therein to x-rays;

15   acquiring ion extraction rate data related to a rate at

16   which photons are detected to be emitted from at least one ion

17   extraction rate data energy channel of said preconcentration

18   cell; and

19   associating said ion extraction rate data with said

20   preconcentration cell.

1   99.   (previously presented) The method of claim 62, further

2   comprising the step of obtaining said calibration data by:

3   filling said preconcentration cell, with a highly purified

4   form of a fluid of interest;

5   exposing the filled preconcentration cell to x-rays;

6   acquiring background data related to a rate at which photons

7   are detected to be emitted from at least one background data

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8   energy channel of said preconcentration cell;

9   filling said preconcentration cell, with a first calibration

10   solution containing at least one element of interest in said

11   fluid of interest in known concentration above a minimum

12   detection level of x-ray detection equipment to be used for said

13   detecting and measuring;

14   exposing the filled preconcentration cell to x-rays;

15   acquiring sensitivity data related to a rate at which

16   photons are detected to be emitted from at least one sensitivity

17   data energy channel of said preconcentration cell;

18   applying said voltage differential across the electrodes of

19   said preconcentration cell, below an electrochemical potential of

20   said at least one element of interest and below an electrolysis

21   potential of a second calibration solution;

22   flowing said second calibration solution containing said at

23   least one element of interest in said fluid of interest in known

24   concentration below a minimum detection level of x-ray detection

25   equipment to be used for said detecting and measuring through the

26   central flow interelectrode gap of said preconcentration cell, at

27   a substantially constant flow rate;

28   exposing said preconcentration cell with said second

29   calibration solution therein to x-rays;

30   acquiring ion extraction rate data related to a rate at

31   which photons are detected to be emitted from at least one ion

32   extraction rate data energy channel of said preconcentration

33   cell; and

34   associating said background data, said sensitivity data, and

37

35   said ion extraction rate data with said preconcentration cell.

1   100.   (previously presented) The method of claim 62, further

2   comprising the steps of:

3   applying said voltage differential across said electrodes

4   below an electrochemical potential of said at least one element

5   of interest and below an electrolysis potential of said fluid,

6   suspected to contain at least one element of interest;

7   flowing said fluid through said central flow interelectrode

8   gap at a substantially constant flow rate;

9   exposing said preconcentration cell with said fluid therein

10   to x-rays; and

11   acquiring said test data related to a rate at which photons

12   are detected to be emitted from at least one test data energy

13   channel of said preconcentration cell.

1   101.   (original) The method of claim 100, further comprising

2   the step of:

3   analyzing   said   test   data   and   deducing   therefrom   a

4   concentration in said fluid, if any, of the suspected at least

5   one element of interest.

1   102.   (previously presented) The method of claim 99, further

2   comprising the steps of:

3   applying said voltage differential across said electrodes

4   below an electrochemical potential of said at least one element

5   of interest and below an electrolysis potential of said fluid,

6   suspected to contain at least one element of interest;

7   flowing said fluid through said central flow interelectrode

8   gap at a substantially constant flow rate;

38

9   exposing said preconcentration cell with said fluid therein

10   to x-rays; and

11   acquiring said test data related to a rate at which photons

12   are detected to be emitted from at least one test data energy

13   channel of said preconcentration cell.

1   103.   (original) The method of claim 102, further comprising

2   the step of:

3   analyzing said test data in relation to said background

4   data, said sensitivity data, and said ion extraction rate data,

5   and deducing therefrom a concentration in said fluid, if any, of

6   the suspected at least one element of interest.

1   104.   (previously presented) The method of claim 62, further

2   comprising the step of:

3   exposing said preconcentration cell to x-rays substantially

4   transmitted through said upper x-ray transmission window, while

5   flowing said fluid and while applying said voltage differential.

1   105.   (previously presented) The method of claim 62, said step

2   of applying said voltage differential further comprising the

3   steps of:

4   ceasing flow of said fluid while applying an electrostatic

5   charge across said electrodes and thereby maintaining ions from

6   said at least one element entrained in said electrodes;

7   transporting said ionic preconcentration cell to an x-ray

8   source means for emitting x-rays toward said preconcentration

9   cell while applying said electrostatic charge; and

10   exposing said preconcentration cell to x-rays from said x-

11   ray source means while applying said electrostatic charge.

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1   106.   (previously presented) The method of claim 62, further

2   comprising the step of:

3   controlling a flow rate of said fluid through said ionic

4   preconcentration cell so as to maintain ε, which designates a

5   predetermined percentage of at least one element of interest to

6   be extracted from said fluid, below approximately 5% for said at

7   least one element of interest. ·

1   107.   (previously presented) The method of claim 106, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

5   4%, 3%, 2%, and 1%.

1   108.   (previously presented) The method of claim 62, further

2   comprising the step of:

3   controlling a flow rate F of said fluid through said ionic

4   preconcentration cell and maintaining said F at a substantially

5   constant level so as to maintain ε, which designates a

6   predetermined percentage of at least one element of interest to

7   be extracted from said fluid and is specified by:

8
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{q\,d}\,\frac{w_i}{w_f}\,\frac{A}{n_f\,CF}\times 100\%\,,$$

9   below approximately 5% for said at least one element of interest;

10   wherein:

11   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

12   one element of interest are respectively extracted from said

13   fluid by said cell and supplied to said cell by said fluid, σ

14   designates a composite conductivity of said fluid, Φ designates

40

15   said voltage differential applied across said electrodes, d

16   designates said predetermined interelectrode gap width of said

17   central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates

18   the unit charge, A designates an ordinary surface area covered by

19   said electrodes, n_f designates a number density of said fluid,

20   w_i and w_f designate atomic / molecular weights, respectively, of

21   said at least one element of interest and of said fluid, and C

22   designates a concentration of said at least one element of

23   interest in said fluid; and

24   having said concentration C in a range where conductivity

25   varies substantially linearly with concentration, with C in units

26   of parts per billion, wherein σ is approximated by:

27       $$\sigma \approx 2 \times 10^{-9} \, C / \text{Ohm} - \text{cm} \,.$$

1   109.   (previously presented)   The method of claim 108, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

5   4%, 3%, 2%, and 1%.

1   110.   (original)   The method of claim 62, further comprising the

2   step of:

3   applying said voltage differential across said electrodes

4   below an electrochemical potential of at least one element of

5   interest and below an electrolysis potential of said fluid.

1   111.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   monitoring a total non-saturated concentration of dissolved

4   ions in said upper and lower high surface area electrodes, by

41

5   monitoring a leakage current from said cell.

1   112.   (previously presented)   The method of claim 111, further

2   comprising the step of:

3   measuring at least one element of interest comprising ultra-

4   low trace, high valence ions in said fluid, based on said

5   detecting the non-saturated saturation state.

1   113.   (previously presented)   The method of claim 62, further

2   comprising the steps of:

3   monitoring a total non-saturated concentration of dissolved

4   ions in said upper and lower high surface area electrodes by

5   monitoring a leakage current in said cell; and

6   adjusting the flow of said fluid through said ionic

7   preconcentration cell to control a percentage of said ions

8   extracted from said fluid, based on said monitoring of said

9   leakage current.

1   114.   (previously presented)   The method of claim 62, further

2   comprising the steps of:

3   setting an impurity concentration C, in a range where

4   conductivity varies substantially linearly with concentration, to

5   a predetermined desired concentration detection level; and

6   controlling how long said fluid flows through said ionic

7   preconcentration cell by flowing said fluid for a time t given

8   by:

9        $t \propto \dfrac{S\ell}{\sigma} \propto \dfrac{S\ell}{C}$, wherein:

10   S designates a sensitivity of x-ray detection equipment to

11 be used for said detecting and measuring;

42

12   ℓ designates a thickness of said upper high surface area

13   electrode; and

14   σ designates a composite conductivity of said fluid.

1   115.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   triggering an action in response to detecting that a

4   concentration of at least one element of interest in said fluid

5   has passed a predetermined, non-saturated threshold

6   concentration.

1   116.   (previously presented)   The method of claim 115, said step

2   of triggering further comprising the step of:

3   maintaining said concentration within a predetermined

4   concentration range by injecting at least one element into said

5   fluid as said action in response to said detecting.

1   117.   (previously presented)   The method of claim 115, said step

2   of triggering further comprising the step of:

3   maintaining said concentration within a predetermined

4   concentration range by diluting at least one diluting fluid into

5   said fluid as said action in response to said detecting.

1   118.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   cleaning said preconcentration cell after use by releasing

4   ions accumulated within said high specific surface area of said

5   electrodes into said fluid, after the accumulated ions have been

6   exposed to x-rays and fluorescence from said preconcentration

7   cell has been detected.

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1   119.   (previously presented)   The method of claim 64, further

2   comprising the steps of:

3   emitting x-rays toward said preconcentration cell

4   substantially transmitted through said upper x-ray transmission

5   window; and

6   detecting fluoresced energy emitted by said preconcentration

7   cell due to said emitting x-rays toward said preconcentration

8   cell, through said upper x-ray transmission window.

1   120.   (previously presented)   The method of claim 119, further

2   comprising the step of:

3   analyzing the detected x-ray fluoresced energy and deducing

4   therefrom a concentration in said fluid of at least one element

5   of interest in said fluid.

1   121.   (previously presented)   The method of claim 62, further

2   comprising the step of:

3   downloading and analyzing said test data from said ionic

4   preconcentration cell using a telecommunications link.

1   122.   (previously presented)   The system of claim 3, wherein:

2   said transportable voltage supply is embedded into a body of

3   said ionic preconcentration cell.

1   123.   (previously presented)   The method of claim 63, further

2   comprising the step of:

3   providing said transportable voltage supply embedded into a

4   body of said ionic preconcentration cell.

1   124-138.   (cancelled)

1   139.   (previously presented)   An ionic preconcentration cell

2   apparatus for identifying and measuring concentrations of

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3   elements in fluids, comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10 lower high surface area electrodes by a predetermined

11 interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13 flow interelectrode gap; and

14   an upper x-ray transmission window in intimate contact with

15 an upper surface of said upper high surface area electrode; said

16 upper x-ray transmission window comprising:

17   an atomic number below 10;

18   structural rigidity to support up to 1/10 atm. of pressure

19 without bowing more than approximately 100 microns;

20   substantial impermeability relative to said fluid;

21   x-ray transparency greater than 90% for characteristic

22 photon energies from an element of interest for which a fluidic

23 concentration is to be measured;

24   x-ray scattering therefrom minimized to less than

25 approximately 10% of radiation scattered from a column of said

26 fluid equal to one optical depth in said fluid of a

27 characteristic photonic energy from an element of interest for

28 which a fluidic concentration is to be measured; and

29   freedom from any single contaminant in excess of 1 part per

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30   million, when measured by x-ray fluorescence.

1   140.   (previously presented)   An ionic preconcentration cell

2   apparatus for identifying and measuring concentrations of

3   elements in fluids, comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10   lower high surface area electrodes by a predetermined

11   interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13   flow interelectrode gap;

14   an upper x-ray transmission window in intimate contact with

15   an upper surface of said upper high surface area electrode; and

16   a lower x-ray transmission window in intimate contact with a

17   lower surface of said lower high surface area electrode; said

18   lower x-ray transmission window comprising:

19   an atomic number below 10;

20   structural rigidity to support up to 1/10 atm. of pressure

21   without bowing more than approximately 100 microns;

22   substantial impermeability relative to said fluid;

23   x-ray transparency greater than 90% for characteristic

24   photon energies from an element of interest for which a fluidic

25   concentration is to be measured;

26   x-ray scattering therefrom minimized to less than

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27   approximately 10% of radiation scattered from a column of said

28   fluid equal to one optical depth in said fluid of a

29   characteristic photonic energy from an element of interest for

30   which a fluidic concentration is to be measured; and

31   freedom from any single contaminant in excess of 1 part per

32   million, when measured by x-ray fluorescence.

1   141-156. (cancelled)

1   157.   (previously presented) A method for identifying and

2   measuring concentrations of elements in fluids, comprising the

3   steps of:

4   flowing a fluid through a central flow interelectrode gap of

5   an ionic preconcentration cell separating an upper high specific

6   surface area electrode from a lower high specific surface area

7   electrode of said ionic preconcentration cell by a predetermined

8   interelectrode gap width;

9   applying a voltage differential between said upper high

10   surface area electrode and said lower high surface area electrode

11   while said fluid is flowing through said central flow

12   interelectrode gap;

13   passing x-rays through an upper x-ray transmission window

14   intimately contacting an upper surface of said upper high surface

15   area electrode;

16   deducing an identity, or measurement of concentration, of at

17   least one element in said fluid based on a response of said

18   preconcentration cell to said x-rays; and

19   providing said upper x-ray transmission window comprising:

20   an atomic number below 10;

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21   structural rigidity to support up to 1/10 atm. of pressure

22 without bowing more than approximately 100 microns;

23   substantial impermeability relative to said fluid;

24   x-ray transparency greater than 90% for characteristic

25 photon energies from an element of interest for which a fluidic

26 concentration is to be measured by said method;

27   x-ray scattering therefrom minimized to less than

28 approximately 10% of radiation scattered from a column of said

29 fluid equal to one optical depth in said fluid of a

30 characteristic photonic energy from an element of interest for

31 which a fluidic concentration is to be measured by said method;

32 and

33   freedom from any single contaminant in excess of 1 part per

34 million, when measured by x-ray fluorescence.

1   158.   (previously presented) A method for identifying and

2   measuring concentrations of elements in fluids, comprising the

3   steps of:

4   flowing a fluid through a central flow interelectrode gap of

5   an ionic preconcentration cell separating an upper high specific

6   surface area electrode from a lower high specific surface area

7   electrode of said ionic preconcentration cell by a predetermined

8   interelectrode gap width;

9   applying a voltage differential between said upper high

10 surface area electrode and said lower high surface area electrode

11 while said fluid is flowing through said central flow

12 interelectrode gap;

13   passing x-rays through an upper x-ray transmission window

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14 intimately contacting an upper surface of said upper high surface

15 area electrode;

16   deducing an identity, or measurement of concentration, of at

17 least one element in said fluid based on a response of said

18 preconcentration cell to said x-rays;

19   passing said x-rays through a lower x-ray transmission

20 window intimately contacting a lower surface of said lower high

21 surface area electrode; and

22   providing said lower x-ray transmission window comprising:

23   an atomic number below 10;

24   structural rigidity to support up to 1/10 atm. of pressure

25 without bowing more than approximately 100 microns;

26   substantial impermeability relative to said fluid;

27   x-ray transparency greater than 90% for characteristic

28 photon energies from an element of interest for which a fluidic

29 concentration is to be measured by said method;

30   x-ray scattering therefrom minimized to less than

31 approximately 10% of radiation scattered from a column of said

32 fluid equal to one optical depth in said fluid of a

33 characteristic photonic energy from an element of interest for

34 which a fluidic concentration is to be measured by said method;

35 and

36   freedom from any single contaminant in excess of 1 part per

37 million, when measured by x-ray fluorescence.

1 159-160. (cancelled)

1 161.   (previously presented) A method of optimizing fabrication

2 of an ionic preconcentration cell for identifying and measuring

3   concentrations of elements in fluids; said ionic preconcentration

4   cell comprising an upper high surface area electrode comprising a

5   high specific surface area thereof; a lower high surface area

6   electrode comprising a high specific surface area thereof; and a

7   central flow interelectrode gap separating said upper and lower

8   high surface area electrodes by a predetermined interelectrode

9   gap width; said method comprising the step of:

10   optimizing said upper high surface area electrode with an

11   upper electrode thickness less than or equal to approximately an

12   optical depth ℓ of said upper high surface area electrode when

13   wetted with a fluid to be flowed through said cell.

1   162. (previously presented) The optimization method of claim

2   161, wherein:

3   said $\ell = 1/(\mu*\rho)$; and wherein:

4   μ designates a mass absorption coefficient of said upper

5   high surface area electrode when wetted with said fluid; and

6   ρ designates a material density of said upper high surface

7   area electrode when wetted with said fluid.

1   163.   (previously presented) The optimization method of claim

2   161, further comprising the step of:

3   optimizing said lower high surface area electrode with a

4   lower electrode thickness less than or equal to approximately an

5   optical depth ℓ of said lower high surface area electrode when

6   wetted with said fluid.

1   164.   (previously presented) The optimization method of claim

2   163, wherein:

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3   said $\ell = 1/(\mu*\rho)$; and wherein:

4   μ designates a mass absorption coefficient of said lower

5   high surface area electrode when wetted with said fluid; and

6   ρ designates a material density of said lower high surface

7   area electrode when wetted with said fluid.

1   165.   (previously presented) A method of optimizing fabrication

2   of an ionic preconcentration cell for identifying and measuring

3   concentrations of elements in fluids; said ionic preconcentration

4   cell comprising an upper high surface area electrode comprising a

5   high specific surface area thereof; a lower high surface area

6   electrode comprising a high specific surface area thereof; and a

7   central flow interelectrode gap separating said upper and lower

8   high surface area electrodes by a predetermined interelectrode

9   gap width; said method comprising the step of:

10   optimizing said upper high surface area electrode with an

11   upper electrode thickness less than or equal to approximately an

12   optical depth ℓ of said upper high surface area electrode when

13   wetted with an element of interest for which a fluidic

14   concentration is to be measured by said cell, in a fluid to be

15   flowed through said cell.

1   166.   (previously presented) The optimization method of claim

2   165, wherein:

3   said $\ell = 1/(\mu*\rho)$; and wherein:

4   μ designates a mass absorption coefficient of said upper

5   high surface area electrode when wetted with said element of

6   interest in said fluid; and

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7   ρ designates a material density of said upper high surface

8   area electrode when wetted with said element of interest in said

9   fluid.

1   167.   (previously presented) The optimization method of claim

2   165, further comprising the step of:

3   optimizing said lower high surface area electrode with a

4   lower electrode thickness less than or equal to approximately an

5   optical depth ℓ of said lower high surface area electrode when

6   wetted with said element of interest, in said fluid.

1   168.   (previously presented) The optimization method of claim

2   167, wherein:

3   said $\ell = 1/(\mu*\rho)$; and wherein:

4   μ designates a mass absorption coefficient of said lower

5   high surface area electrode when wetted with said element of

6   interest in said fluid; and

7   ρ designates a material density of said lower high surface

8   area electrode when wetted with said element of interest in said

9   fluid.

1   169-176.   (cancelled)

1   177.   (previously presented) A method of optimizing fabrication

2   of an ionic preconcentration cell for identifying and measuring

3   concentrations of elements in fluids; said ionic preconcentration

4   cell comprising an upper high surface area electrode comprising a

5   high specific surface area thereof; a lower high surface area

6   electrode comprising a high specific surface area thereof; and a

7   central flow interelectrode gap separating said upper and lower

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8   high surface area electrodes by a predetermined interelectrode

9   gap width; said method comprising the step of:

10   optimizing said central flow interelectrode gap comprising

11   said predetermined interelectrode gap width, designated d, within

12   an interelectrode gap range specified by:

13   $$d = \frac{\sigma}{q} \frac{\Phi}{\varepsilon} \frac{w_i}{w_f} \frac{A}{n_f \, CF} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F} ; \quad \text{wherein:}$$

14   ε designates a predetermined percentage of at least one

15   element of interest to be extracted from a fluid to be flowed

16   through said cell, σ designates a composite conductivity of said

17   fluid, Φ designates a voltage differential applied across said

18   electrodes, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A

19   designates an ordinary surface area covered by said electrodes,

20   n_f designates a number density of said fluid, w_i and w_f designate

21   atomic / molecular weights, respectively, of said at least one

22   element of interest and of said fluid, C designates a

23   concentration of said at least one element of interest in said

24   fluid, and F designates a flow rate of said fluid through said

25   ionic preconcentration cell;

26   said high surface area electrodes further comprise said

27   ordinary surface area A approximately equal to an interrogation

28   spot area of x-rays to which said preconcentration cell is to be

29   exposed;

30   said ε is chosen to be below approximately 5% for said at

31   least one element of interest;

32   said Φ is chosen to be below an electrochemical potential of

33   said at least one element of interest and below an electrolysis

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34 potential of said fluid;

35   said F is chosen to exert no more than approximately .1 atm

36 of pressure upon an upper x-ray transmission window of said ionic

37 preconcentration cell in intimate contact with an upper surface

38 of said upper high surface area electrode;

39   said n_f and said w_f are chosen with reference to said at

40 least one element of interest; and

41   said w_i is chosen with reference to said fluid.

1 178.   (previously presented) The optimization method of claim

2 177, wherein:

3   as a consequence of said optimizing, said central flow

4 interelectrode gap comprises said predetermined interelectrode

5 gap width, d, with:

6   a minimum gap width selected from a minimum gap width group

7 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

8   a maximum gap width selected from a maximum gap width group

9 consisting of 2 mm, 5 mm, and 10 mm.

1 179-190 (cancelled)

1 191.   (previously presented) An ionic preconcentration cell

2 apparatus for identifying and measuring concentrations of

3 elements in fluids, comprising:

4   an upper high surface area electrode comprising a high

5 specific surface area thereof;

6   a lower high surface area electrode comprising a high

7 specific surface area thereof, substantially parallel to said

8 upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

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10   lower high surface area electrodes by a predetermined

11   interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13   flow interelectrode gap; and

14   flow control means for controlling a flow rate of said fluid

15   through said ionic preconcentration cell so as to maintain ε,

16   which designates a predetermined percentage of at least one

17   element of interest to be extracted from said fluid, below

18   approximately 5% for said at least one element of interest.

1   192.   (previously presented) The apparatus of claim 191,

2   wherein said ε is maintained below an extraction percentage

3   selected from an extraction percentage group consisting of

4   approximately 4%, 3%, 2%, and 1%.

1   193.   (previously presented) The apparatus of claim 191,

2   further comprising:

3   voltage application means for applying a voltage

4   differential between said upper high surface area electrode and

5   said lower high surface area electrode while said fluid is

6   flowing through said central flow interelectrode gap; and

7   said flow control means for controlling said flow rate F of

8   said fluid through said ionic preconcentration cell and

9   maintaining said F at a substantially constant level so as to

10   maintain said ε, which is specified by:

11        $$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{qd}\,\frac{w_i}{w_f}\,\frac{A}{n_f\,CF} \times 100\%\,,$$

12   below approximately 5% for said at least one element of interest;

13   wherein:.

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14   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

15   one element of interest are respectively extracted from said

16   fluid by said cell and supplied to said cell by said fluid, σ

17   designates a composite conductivity of said fluid, Φ designates

18   a potential applied by said voltage application means across said

19   electrodes, d designates said predetermined interelectrode gap

20   width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$

21   Coulomb designates the unit charge, A designates an ordinary

22   surface area covered by said electrodes, n_F designates a number

23   density of said fluid, w_i and w_F designate atomic / molecular

24   weights, respectively, of said at least one element of interest

25   and of said fluid, and C designates a concentration of said at

26   least one element of interest in said fluid; and

27   for having said concentration C in a range where

28   conductivity varies substantially linearly with concentration,

29   with C in units of parts per billion, wherein σ is approximated

30   by:

31        $\sigma \approx 2 \times 10^{-9} C / Ohm - cm$.

1   194.   (previously presented)   The apparatus of claim 193,

2   wherein said ε is maintained below an extraction percentage

3   selected from an extraction percentage group consisting of

4   approximately 4%, 3%, 2%, and 1%.

1   195.   (previously presented)   A method for identifying and

2   measuring concentrations of elements in fluids, comprising the

3   steps of:

4   flowing a fluid through a central flow interelectrode gap of

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5   an ionic preconcentration cell separating an upper high specific

6   surface area electrode from a lower high specific surface area

7   electrode of said ionic preconcentration cell by a predetermined

8   interelectrode gap width;

9   applying a voltage differential between said upper high

10   surface area electrode and said lower high surface area electrode

11   while said fluid is flowing through said central flow

12   interelectrode gap;

13   exposing said cell to x-rays;

14   deducing an identity, or measurement of concentration, of at

15   least one element in said fluid based on a response of said

16   preconcentration cell to said x-rays; and

17   controlling a flow rate of said fluid through said ionic

18   preconcentration cell so as to maintain ε, which designates a

19   predetermined percentage of at least one element of interest to

20   be extracted from said fluid, below approximately 5% for said at

21   least one element of interest.

1   196.   (previously presented) The method of claim 195, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

5   4%, 3%, 2%, and 1%.

1   197.   (previously presented) The method of claim 195, said step

2   of controlling said flow rate further comprising the step of:

3   controlling said flow rate F of said fluid through said

4   ionic preconcentration cell and maintaining said F at a

5   substantially constant level so as to maintain said ε, which is

6   specified by:

7    $$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi}{q d} \frac{w_i}{w_f} \frac{A}{n_f C F} \times 100\% \, ,$$

8   below approximately 5% for said at least one element of interest;

9   wherein:

10   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

11   one element of interest are respectively extracted from said

12   fluid by said cell and supplied to said cell by said fluid, σ

13   designates a composite conductivity of said fluid, Φ designates

14   said voltage differential applied across said electrodes, d

15   designates said predetermined interelectrode gap width of said

16   central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates

17   the unit charge, A designates an ordinary surface area covered by

18   said electrodes, n_f designates a number density of said fluid,

19   w_i and w_f designate atomic / molecular weights, respectively, of

20   said at least one element of interest and of said fluid, and C

21   designates a concentration of said at least one element of

22   interest in said fluid; and

23   having said concentration C in a range where conductivity

24   varies substantially linearly with concentration, with C in units

25   of parts per billion, wherein σ is approximated by:

26   $\sigma \approx 2 \times 10^{-9} \, C / \text{Ohm} - \text{cm} \, .$

1   198.   (previously presented)   The method of claim 197, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

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5   4%, 3%, 2%, and 1%.

1   199.   (previously presented) An ionic preconcentration cell

2   apparatus for identifying and measuring concentrations of

3   elements in fluids, comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10   lower high surface area electrodes by a predetermined

11   interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13   flow interelectrode gap; and

14   time control means for controlling how long said fluid flows

15   through said ionic preconcentration cell based on setting an

16   impurity concentration C, in a range where conductivity varies

17   substantially linearly with concentration, to a predetermined

18   desired concentration detection level and flowing said fluid for

19   a time t given by:

20       $$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C};$$ wherein:

21   S designates a sensitivity of x-ray detection equipment to

22   be used for said detecting and measuring;

23   ℓ designates a thickness of said upper high surface area

24   electrode; and

25   σ designates a composite conductivity of said fluid.

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1   200.   (previously presented) A method for identifying and

2   measuring concentrations of elements in fluids, comprising the

3   steps of:

4   flowing a fluid through a central flow interelectrode gap of

5   an ionic preconcentration cell separating an upper high specific

6   surface area electrode from a lower high specific surface area

7   electrode of said ionic preconcentration cell by a predetermined

8   interelectrode gap width;

9   applying a voltage differential between said upper high

10 surface area electrode and said lower high surface area electrode

11 while said fluid is flowing through said central flow

12 interelectrode gap;

13   exposing said cell to x-rays;

14   deducing an identity, or measurement of concentration, of at

15 least one element in said fluid based on a response of said

16 preconcentration cell to said x-rays;

17   setting an impurity concentration C, in a range where

18 conductivity varies substantially linearly with concentration, to

19 a predetermined desired concentration detection level; and

20   controlling how long said fluid flows through said ionic

21 preconcentration cell by flowing said fluid for a time t given

22 by:

23      $t \propto \dfrac{S\ell}{\sigma} \propto \dfrac{S\ell}{C}$, wherein:

24   S designates a sensitivity of x-ray detection equipment to

25 be used for said identifying and measuring;

26   ℓ designates a thickness of said upper high surface area

27   electrode; and

28   σ designates a composite conductivity of said fluid.

1   201.   (new)   The system of claim 1, said calibration data

2   further comprising:

3   background data comprising data related to a rate at which

4   photons are detected to be emitted from at least one background

5   data energy channel of said preconcentration cell, when said

6   preconcentration cell is filled with a highly purified form of a

7   fluid of interest and exposed to x-rays.

1   202.   (new)   The method of claim 62, further comprising the step

2   of obtaining said calibration data by:

3   filling said preconcentration cell with a highly purified

4   form of a fluid of interest;

5   exposing the filled preconcentration cell to x-rays; and

6   acquiring background data related to a rate at which photons

7   are detected to be emitted from at least one background data

8   energy channel of said preconcentration cell; and

9   associating said background data with said preconcentration

10   cell.